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A Summary of Current Program, 7/1/62

and Preliminary Report of Progress

for 10/1/60 to 6/30/62

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CLOTHING AND HOUSING RESEARCH DIVISION

of the

AGRICULTURAL RESEARCH SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE

This progress report of USDA and cooperative research is primarily a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

There is included under each problem area in the report a brief and very general statement on the nature of the research being conducted by the State Agricultural Experiment Stations and the professional manpower being devoted by the State stations to such research. Also included is a brief description of related work conducted by private organizations. No details on progress of State station or industry research are included except as such work is cooperative with USDA.

The summaries of progress on USDA and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members, and others having a special interest in the development of public agricultural research programs.

This report also includes a list of publication reporting results of USDA and cooperative research issued between October 1, 1960 and June 30, 1962. Current agricultural research findings are also published in the monthly USDA publication, Agricultural Research. This progress report was compiled in the Clothing and Housing Research Division, Agricultural Research Service, U. S. Department of Agriculture, Beltsville, Maryland.

UNITED STATES DEPARTMENT OF AGRICULTURE

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INTRODUCTION

Clothing and housing research, as used in this report, covers the identification and quantitative evaluation of consumer needs in relation to selection, use, and care of clothing and housing. This includes study of requirements and development of functional designs for clothing and for house interiors, and the research required for the preparation of consumer guides leading to improved selection, use, and home care of clothing, housefurnishings, and housing interiors. Attention is given to consumer-use aspects of fabrics made of cotton, wool, and other fibers.

Clothing and housing form the immediate protective environment in which people live and work; they directly affect efficiency, comfort, and general well-being. From this point of view, clothing and housing are of national concern. Expenditures for clothing in 1961 were estimated at about 10 percent of total personal consumption; for housing, about 13 percent; and for household operation and equipment, about 14 percent. Some 40 percent of family expenditures for apparel and housefurnishings represent cotton and 37 percent represent wool, according to weights assigned to cotton, wool, and manmade fibers in the Consumer's Price Index of the U. S. Department of Labor.

USDA research in the field of clothing and housing is concerned with fundamental biological, chemical, and physical principles, and their application to solving the problems of consumers. Research findings are made available to the scientific public through papers presented at professional meetings and through technical publications;

and to teachers, extension workers, and other leaders who are concerned with helping families and consumers, through semitechnical reports. Information obtained from USDA research is incorporated with pertinent information from other sources and published, in cooperation with information specialists of the Department, in forms helpful to consumers. Collaboration with technical committees of such organizations as the American Association of Textile Chemists and Colorists, the American Society for Testing Materials, and the American Standards Association, provides for consideration of scientific findings and mutual problems by governmental, industrial, and other research workers.

Two examples of recently completed research are given below to illustrate the nature of the program and the way in which scientific findings are disseminated in forms suitable not only for research workers but also for educators, administrators, and consumers:

CLOTHING problems of physically handicapped housewives who wear braces, use crutches, or work in wheelchairs were identified on the basis of interviews with interested homemakers whose names were suggested by local rehabilitation and other health agencies. Principles of clothing design and construction applicable in solving the problems encountered by these women were identified by the research staff and applied in designs developed in the laboratories at Beltsville, Md. Both handicapped and normal women cooperated in evaluating the performance of clothing designed and constructed to embody these principles. The special features of construction, found effective in providing comfort, freedom of movement, safety, convenience, and self reliance for the millions of women who face physical handicaps have been reported through publications, exhibits of garments and photographs, workshops, and other means. Home economists, therapists, nurses, and other professional groups concerned with the needs of the disabled and the elderly are using the findings, both in this country and abroad. Garment and pattern manufacturers also are showing interest, particularly in possibilities for application of the special design features to "action" clothing for normal women.

HOUSING problems in respect to space within the house were identified through regional field studies of the kind and scope of household activities that farm-operator families throughout the nation carry on in their homes and what they have in the way of possessions to store. Through controlled laboratory studies, the dimensions of space needed on the floor, on work surfaces, and in storage areas were determined for practically all major household activities, including food preparation, laundering, cleaning, sewing, and recreation. Recommended space allowances were developed on the basis of the findings of these several studies

which, like the field surveys, were conducted in cooperation with State Agricultural Experiment Stations. Recommendations for dimensions and arrangement of space were published in graphic forms for use by farmers and their wives, and by architects, builders, educators, lending agencies, and others who are concerned with rural housing. Results of the research are of particular interest at present in helping rural families who are taking advantage of provisions of the Housing Act of 1961.

As a result of widespread interest in results of both of the above types of research, requests are being received for information related to the clothing needs of other handicapped groups such as crippled children; and to the housing needs of other rural people, especially the aging, and the low-income groups in distressed areas.

* * * * *

Clothing and housing research is carried out by the Clothing and Housing Research Division of the Agricultural Research Service of the U. S. Department of Agriculture, 31 of the 53 Experiment Stations 1/, manufacturers of household equipment and textiles, and private consumer organizations. Brief statements of the problems to be solved, the research programs of the USDA, the State Experiment Stations, industry, and other organizations will be found under each of the area headings shown in the Table of Contents. A progress report is given on the research of USDA only.

1 Connecticut and New York have two stations and the University of Puerto Rico at Rio Piedras has State station status.

AREA NO. 1. CLOTHING, HOUSEHOLD TEXTILES, AND FABRICS
FOR CONSUMER USE

Problem. As a result of the ever increasing variety of clothing, household textiles, and fabrics for home sewing, decision-making by consumers is becoming more and more difficult. The Textile Fiber Products Identification Act which became effective in March 1960 makes mandatory the labeling of textile products as to fiber content, but this only partially solves the problem. Consumers need to know what properties are imparted to textiles by different classes of fibers, fiber blends, fabric constructions and finishes, and what properties are needed in textiles for satisfactory performance in specific uses. For guidance in selecting readymade items and in home sewing, consumers also need to know what types of construction features, such as seams and edge finishes, are suitable for use with various fabrics and in various items. Other needs are for improved systems of sizing for patterns and readymade garments and for the development of garment features that contribute to comfort of the wearer, safety, efficiency, and other functional characteristics.

To supply such information, continuing research is needed to identify and quantify the relationship between the properties of fabrics and of readymade textile articles and their performance characteristics; and to provide data on body measurements basic to the development of improved sizing systems. In addition to aiding consumers, results could enable manufacturers to assess more accurately what products will be most profitable in the long run because they are most likely to provide consumer satisfaction.

USDA PROGRAM

The Department has a continuing research program, involving a cooperative effort of physicists, chemists, and home economists, to determine relationships of physical properties of fabrics to their construction, fiber content, and finish, and to their performance in use as clothing or household textiles. Changes in appearance and other properties during use are followed subjectively by trained evaluation panels and objectively by the use of appropriate instruments and laboratory procedures. Rapid and dependable methods for predicting performance in use are sought. Principles of construction for use in making clothing and household textiles from modern fabrics are developed through laboratory investigation. Clothing problems of both normal and handicapped individuals are identified through interviews and observations, and garment features are designed to solve these problems.

The Department's research facilities are located at Beltsville, Md.

The Federal scientific effort devoted to research in this area totals approximately 6.0 professional man-years.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations have been concerned with a variety of investigations, some basic, others practical in nature.

Basic research is continuing toward determining whether properties of the raw fiber, such as length, strength, fineness, and elongation in cotton, or fineness and crimp in wool, have bearing on the performance of the loomed fabrics either in actual wear or in response to appropriate laboratory tests. Another investigation is concerned with the relationship of cotton yarn strength and fabric construction to fabric strength. These studies have involved both regional and individual station researches.

Other basic research on a regional basis is attempting, through controlled laboratory experiments, to determine the degree to which climatic variables such as temperature, light, and atmospheric pollutants are responsible for weathering degradation of cotton fabrics loomed from selected Western cotton varieties.

Additional studies are concerned with such problems as the relationships between heat treatments, and the yellowing of synthetic fibers and changes in other physical properties; and with factors responsible for differences in the summertime comfort quality of cotton garments and those of synthetic fibers.

Regional research concerned with consumer satisfactions with clothing in relation to consumer practices in selection, use, and care, has resulted in the formulation of specific hypotheses regarding certain basic components of satisfaction and their relation to overall satisfactions. Research has been undertaken to test these hypotheses and determine whether they have general applicability. Still another study, involving the testing of men's work clothing, suggests that satisfaction or dissatisfaction may be related to certain elements of garment performance and certain attitudes concerning care and maintenance of clothing.

Other regional research has investigated criteria used by mothers and daughters for selection and use of clothing of the adolescent girl. In this research, and other studies discussed, fabric performance has been evaluated by standard physical testing methods paired against expressions of consumer satisfaction and also actual wear tests. These researches are pointing up the need for critical selection or modification of laboratory test procedures the better to serve in prediction of fabric or garment performance and consumer satisfaction. At the same time, there is need for better standardization of wear tests for comparing actual performance with predicted.

A number of practical investigations have provided information for consumer guidance in selection and care of blankets of all-wool, wool blends, or various manmade fibers; tufted rugs of wool, cotton, or manmade fibers; and wash-wear cottons and cotton blends. Another study dealt with construction problems associated with the handling of the newer fabrics.

These researches, involving the efforts of 26 Stations, have totaled 12.7 professional man-years.

Industry and other organizations also conduct research in this field. Some department stores and mail order houses have extensive testing programs to provide a basis for their purchases of fabrics, apparel, and household textiles. Methods developed in the course of the work are sometimes made available to the scientific public through publication in technical journals, or through the work of research or technical committees of professional organizations. In connection with product development and evaluation, manufacturers of textile fibers, threads, yarns, fabrics, finishes, and readymade garments, soft floor coverings, and other textile items, study the performance of textiles, both in service and in the laboratory, developing methods of testing as needed. Results from the research of these manufacturers are supplied to companies using their products but are not usually available to other scientists or to the consumer. Estimated annual expenditures are equivalent to approximately 20 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Cotton, Including Blends and Mixtures

1. Knit fabrics. As previously reported, tricot knit fabrics of cotton, acetate, and viscose were studied to relate the details of their construction and that of the yarns from which they were made to their bursting strength, elastic behavior, and dimensional stability in laundering. Results have now been published as a technical article in the Textile Research Journal.

Raschel knit fabrics used in further, recently completed research on the relation between the geometry of fabrics and their properties included a total of 32 cotton fabrics knit to specification by the School of Textiles at North Carolina State College. They represented the following six types of construction: straight chaining with lay-in; ordinary stitch with lay-in; 2-bar Atlas with skip entry; 2-bar jersey with skip entry; straight chaining with ordinary stitch; and eyelet mesh with irregular entry. These fabrics were found to resemble filling knits and other types of warp knits studied previously in that they exhibited excessive dimensional changes in laundering unless the distortions present in the fabrics as they came from the knitting plant were reduced by manual relaxation. Without relaxation, the

raschel knits showed from 10 to 29 percent shrinkage in length in five launderings and from 11 percent shrinkage to 56 percent stretch in width. After manual relaxation, dimensional change in laundering usually did not exceed five percent. The results suggest that raschel fabrics of improved dimensional stability could be produced by use of a suitable finishing treatment in the mill.

The ratio of wale spacing to course spacing in the relaxed raschel fabrics varied from 0.8 to 2.1. In this characteristic, they differed from the plain and tricot knits previously studied in which the ratio of wale spacing to course spacing was always approximately 1.1 in the relaxed fabrics.

The bursting strength of the open knit types of raschel fabric was considerably less than that of the firm, closely-knit types, and for each type, bursting strength increased with the number of courses per inch: the weakest fabrics showed a strength of 26 pounds; the strongest, 109 pounds.

In elongation, immediate elastic recovery, and permanent set, the fabrics showed much greater variation in the widthwise direction than in the lengthwise direction. For example, for a 2.5-pound load, six of the fabrics varied in elongation from 24 to 33 percent in the lengthwise direction, and from 27 to 117 percent in the widthwise direction; in immediate elastic recovery from 34 to 41 percent in the lengthwise direction and from 16 to 30 percent in the widthwise direction; and in permanent set from 10 to 22 percent in the lengthwise direction and from 16 to 54 percent in the widthwise direction. For each type of raschel fabric, the tighter knits had somewhat greater elastic recovery and less permanent set than the loosely knit fabrics. Results of this research were summarized in a talk at the annual meeting of the American Home Economics Association in June 1961, and in an article published by the Textile Research Journal in 1962.

Filling knit fabrics are now under study in cooperation with the Spring City Knitting Company to determine the effects of staple length, mercerization, and blending with nylon on the end-use qualities of knitted cotton fabrics. Twenty-two fabrics, consisting of a plain knit and the corresponding 1x1 rib knit made from each of 11 different yarns, are being worn in the form of T-shirts and briefs by employees of the Spring City Knitting Company, and by inmates of the Pennhurst State School at Spring City, Pa. The original fabrics and fabrics from garments that have been subjected to 10, 20, and 30 periods of wear and laundering are being evaluated at Beltsville with respect to bursting strength, weight, color, and resistance to abrasion. Results are expected to provide a basis for 1) guidance to manufacturers as to the effects of the variables studied upon performance characteristics of the fabrics, and

2) consumer-oriented information concerning the relative utility of knit fabrics of mercerized cotton, cottons of different staple length, and cotton-nylon blends.

2. Fabrics for specific uses in clothing and household textiles. Shirting fabrics made from Deltapine 15 cotton of middling grade and 1-1/16-inch staple were used to explore the effect of yarn and cloth construction upon physical properties and in-service performance. Statistical evaluation of the data has been completed and results are being prepared for publication.

Dyed cotton pile carpeting was used in an investigation of changes in color and general appearance resulting from soiling and cleaning. Comparable pieces of a good quality of cotton broadloom were dyed to opposite hues of specified values and chromas. The Munsell Notations and the Inter-Society Color Council-National Bureau of Standards Color Designations for the dyed carpeting follow: 5 YR 8/4 (light yellowish pink); 5 YR 6/4 (light brown); 5 YR 4/4 (moderate brown); 5 YR 6/6 (moderate orange); 5 B 8/4 (very light greenish blue); 5 B 6/4 and 5 B 6/6 (light greenish blue); 5 B 4/4 (moderate greenish blue). For each Munsell Notation, two dyeings were carried out--one under the supervision of a cooperating scientist of the E. I. du Pont de Nemours & Company, Inc., and one by a commercial dyeing plant. Rugs from the undyed and dyed carpeting were evaluated by a judging panel and with the Color and Color Difference Meter during and after three different treatments, namely: 1) placed in service in the Beltsville cafeteria for ten 2-day periods where approximately 400 persons walked over the rugs each day, vacuumed daily, and washed in a commercial rug cleaning plant after each 2-day period; 2) put in service for 10 consecutive 2-day periods, vacuumed daily, and washed at the end of the 20 days; 3) soiled 10 times by an accelerated method, through cooperative work by the National Institute of Rug Cleaning, and washed after each soiling. By the end of the study, all rugs of the undyed carpeting and most of the dyed carpeting (approximately 88 percent) showed noticeable change in color but none showed abrasive wear. The greatest degree of soil in the dyed rugs was shown by those that were lightest in color. In many instances, changes in color due to soil as measured by the Color and Color Difference Meter were low in relation to the visual ratings. An informal discussion of the work was given at a seminar at Cornell University in May 1961. A paper reporting the findings has been accepted for publication in the Journal of Home Economics.

B. Clothing Design in Relation to Functional Requirements and Use

Garments and garment features to meet functional needs were developed, as previously reported, during research on the clothing problems of physically limited homemakers. Dissemination of the research findings was continued in response to requests from many sources. Demonstrations were given to a number of professional workshops and groups including therapists, physicians, rehabilitation nurses and consultants, social and public health workers, and home economists. The results were the subject of articles and news items in a number of publications of such groups. Collections of the garments which were made for loan to groups concerned with the needs of those afflicted by disabilities and to interested manufacturers of garments and patterns are in use continuously.

Clothing problems and needs of children during their formative years are being investigated in recently initiated research. The problems and needs of both normal and physically handicapped youngsters will be studied as a basis for developing appropriate garments and features of garments to meet functional needs. This is a continuation and expansion of pioneering research directed to the physical and educational potentials of clothing for children, which was conducted by the Department about 25 years ago.

C. Principles of Construction of Clothing and Household Textiles

Puckering of seams in garments made from today's "easy-care" fabrics is the cause of much dissatisfaction among consumers, and is of great concern to women who sew for themselves and their families, and to manufacturers of garments and fabrics. Causes were investigated and ways developed for preventing puckering when using cotton fabrics with "easy-care" finishes. Seams involving different combinations of thread, fabric, and sewing machine adjustments were made and evaluated with respect to puckering, both subjectively and objectively, before and after repeated home-type laundering. Fabrics of different construction and finish, and threads of different fiber content, finish, and percent elongation used in the work were obtained through cooperation with thread and fabric manufacturers and the Southern Utilization Research and Development Division. Statistical analysis of the data is in progress.

Fraying and pulling out of seams cause a large number of garment failures. The durability of selected seam finishes in representative cotton clothing fabrics was, therefore, investigated. Four seam finishes of a type commonly used in both readymade and homemade garments were applied to 10 staple cotton clothing fabrics differing widely in construction and finish. The experimental constructions were tested for resistance to repeated home-type laundering and to

the random-motion abrasion of the Accelerotor. Seams finished with a zigzagged edge finish (a row of zigzag machine-stitching $\frac{3}{8}$ inch from the plain machine-stitching of the seam) showed no detectable fraying on repeated laundering, or in the Accelerotor; double-stitched seams (a second row of plain machine-stitching $\frac{1}{4}$ inch from the first) frayed only as far as the outer row of stitching; plain (unfinished) seams frayed more than pinked seams; and crosswise (fillingwise) seams frayed more than did lengthwise (warpwise) seams. Curved seams frayed more in laundering than straight (crosswise or lengthwise) seams, but the opposite results were obtained in the Accelerotor. A report of the findings is in preparation.

D. Information for Consumer Guidance

1. Clothing. Home Economics Research Report No. 1 "Clothing Fabrics-- facts for consumer education," issued in 1957 to provide unbiased practical help in the selection and use of fabrics for various purposes, continues to be in great demand. A manuscript bringing this publication up to date was prepared and is now in clearance in the Department. Information was added on new fibers, fabric constructions and finishes, and on the rules and regulations pertaining to the labeling of textile products which were established by the Federal Trade Commission as a result of enactment of the Textile Fiber Products Identification Act of 1960.

Although large sums of money are spent annually for children's shoes, the product purchased is frequently unsatisfactory as to "fit" and/or serviceability. An exploratory study was recently initiated to determine what information is available on the dimensions of children's feet, the serviceability of various shoe types and components, and the relationship of shoe designs and materials to foot development and comfort. Pertinent literature is being reviewed, organizations engaged in research are being canvassed to obtain information on unpublished research, and an annotated bibliography is being prepared for use in planning further research directed toward the solution of consumer problems on children's shoes.

Procedures for repairing clothing and altering patterns are described in two of the Department's popular-type publications issued in the midforties to meet a wartime need but still in great demand, even though badly in need of up-dating. Field and laboratory investigations are under way to obtain information necessary for revising these publications. Special attention is being directed to problems presented by garments and garment features that have come into widespread use since the original publications were issued, and by fabrics of newer fibers, finishes, and constructions. The work is also providing information on causes of garment failure.

2. Household textiles. An exploratory study of the serviceability of 35 typical slipcover fabrics was completed. The fabrics represented a variety of fibers, constructions, colors, and prices. When new, they were tested in the laboratory for resistance to abrasion and breaking strength, and their weight, thickness, and thread count were determined. After approximately 3,000 hours of use as covers on seat cushions in a cafeteria at Beltsville, Md., the fabrics were judged on the basis of their appearance by an evaluation panel and placed in three categories, namely: 1) in excellent condition; 2) suitable for continued use although not in excellent condition; and 3) no longer suitable for use.

It was found that the 13 fabrics still in excellent condition at the end of the study, when new, averaged higher than the others in resistance to abrasion and breaking strength, and were of greater weight, thickness, and thread count. The 10 fabrics no longer suitable for use at the end of the study, when new, averaged relatively low in these properties.

The individual fabrics varied widely, however. For example, the original abrasion resistance of eight of the 13 fabrics that were rated excellent was lower than the average original abrasion resistance of the 12 fabrics rated suitable for further use and, in turn, the original abrasion resistance of five of these usable fabrics was lower than the average original abrasion resistance of the fabrics that were considered no longer usable.

The results show that breaking strength and resistance to abrasion are important characteristics for slipcover fabrics but tests for other types of properties such as colorfastness and tendency to fuzz and pill should also be used in evaluating fabrics for use in slipcovers.

Window curtains, long an important item in the homefurnishing budget, have become even more important with present-day construction of homes with large glass areas, where curtains requiring large amounts of fabric are needed to control light and provide privacy and insulation. Using pertinent information from previous work and obtaining additional information as needed by experimentation, procedures are being developed for estimating yardage, cutting, making, and hanging draw curtains. Special attention is being given to problems presented by windows of large dimensions and by the use of patterned fabrics. This includes the development of procedures for retaining the original design motifs and obtaining the desired degree of fullness with a minimum of waste.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Cotton, Including Blends and Mixtures

Fletcher, H. M., and Roberts, S. H. 1961. The geometry and properties of two-bar tricot fabrics of acetate, viscose, and cotton. Text. Res. Jour., 31(2), pp. 151-159, illus.

Fletcher, H. M., and Roberts, S. H. 1962. Geometry and properties of cotton two-bar raschel fabrics. Text. Res. Jour., 32(3), pp. 173-180, illus.

Clothing Design in Relation to Functional Requirements and Use

Scott, C. L. 1960. Clothes for the physically handicapped home-maker. Abstract in Proceedings of AHEA Pre-Convention Workshop--Expanding the Services of the Home Economist in Rehabilitation. pp. 42-45, illus.

Scott, C. L. 1961. Clothes for the physically handicapped home-maker. USDA Home Economics Research Report No. 12, 28 pp.

Scott, C. L., and Smith, M. 1962. Clothing. USDA Yearbook of Agriculture, pp. 670-674.

Information for Consumer Guidance

Smith, M. 1962. New developments in functional clothing fabrics. Family Economics Review, ARS 62-5, March, pp. 5-7.

AREA NO. 2. HOUSEHOLD MAINTENANCE OF TEXTILE PRODUCTS

Problem. Because the family's supply of clothing and household textile items represents a considerable initial investment, and requires a continuing expenditure in time and money for maintaining it in good condition, there is much demand for research-based information on selection and appropriate use of agents such as detergents, bleaches, and fluorescent brighteners for household use. Also in demand is information on the nature of the soils and on environmental and other factors, including microorganisms, which accelerate or inhibit undesirable changes in appearance or other properties of textile materials. As textiles are potential disseminators of pathogenic and odor-producing microorganisms, investigations are needed on methods, suitable for home use, for controlling such transmission, and on the interrelationships of bacteria and fabrics.

USDA PROGRAM

The Department has a continuing program involving chemical and bacteriological investigations of factors affecting the soiling of fabrics, the redeposition of soil and microorganisms during laundering, and the removal of soils from fabrics. Included are studies on the 1) identity of soils and microorganisms present on used items of clothing and household textiles, and 2) effectiveness of various compounds or formulations in removing soil and microorganisms, maintaining whiteness, and preventing undesirable changes in appearance and other properties. Fabrics differing in construction, fiber content, and finish are used in the work. Families and individuals cooperate in studies of natural soiling and of laundering under actual home conditions.

The research effort, conducted at Beltsville, Md., totals 6.0 professional man-years.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations have studied factors related to bleaching practices in home laundering, the effects of fabric softeners on fabric properties, and also the effects of commercial laundering practices on fabric properties. Work in this area, located in two Stations, has involved only 0.6 professional man-year.

Manufacturers of products used in laundering and disinfection of clothing and household textiles devote considerable time to product development and evaluation. They study the effectiveness of chemically different types of surface-active agents, bleaches, fluorescent whiteners, builders, and antimicrobial agents when used on textiles. Because of the highly competitive nature of the products, the results of such work are not usually published. Test methods developed in the course of the work, however, are sometimes made available to the scientific public through technical journals, or through research or technical committees of various scientific societies, such as the Chemical Specialties Manufacturers Association, the American Association of Textile Chemists and Colorists, the American Society for Testing Materials, and the Inter-Society Color Council.

Annual expenditures on development of test methods are estimated at approximately 10.0 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Detergents, Bleaches, and Other Agents

Fluorescent whitening agents are now present in most household detergents and in much finished yard goods, but little information on these agents is generally available. The whitening effects of such agents when used under conditions simulating home-type laundering are being studied. Ten commercially available whitening agents which include whiteners of five chemical types are being used with cotton, resin-finished cotton, nylon, polyester, polyester and cotton, and triacetate and cotton fabrics.

The whiteness (or brightness) produced by washing swatches of the fabrics in solutions of detergent and whitening agent 5, 10, 15 and 20 times was evaluated subjectively by a judging panel, and objectively by measurements on the Whiteness Reflectometer and the Color and Color Difference Meter. The results of this phase of the work are being summarized and a technical report is in preparation. Studies on the effects produced by use of wash solutions containing hypochlorite or perborate bleach as well as whitening agents and detergents are in progress.

As a supplement to this work, the same subjective and objective examinations were made for the Southern Utilization Research and Development Division as part of their research on use of whiteners in the "wash-wear" finishing of cotton fabrics. Data from the Clothing and Housing Research Division showed that approximately the same effect was achieved by SURDD when the whitening agent was added with the finishing agent as when it was added before the application of the finish. The whitening agent was less

effective when it was applied after the finish. The amount of whitening and its durability to laundering varied with the chemical nature of the whitening agents. This cooperative work was reported at the 1961 National Convention of the American Association of Textile Chemists and Colorists.

B. Disinfection and Protection from Damaging Organisms

Antimicrobial agents in home laundering. Research to develop home methods for preventing the spread of disease-producing organisms by clothing and household textiles was continued. The problem of quantitative release of bacteria from fabrics was solved through development of new procedures involving maceration of inoculated fabrics in a Waring Blendor with the cutting blades reversed, thus making the microorganisms available for enumeration by conventional bacteriological techniques. Application of this procedure to swatches of wool blanketing, cotton sheeting, and acetate tricot which had been inoculated with known numbers of Staphylococcus aureus, Escherichia coli, and Mycobacterium butyricum, and then stored or laundered under controlled conditions provided quantitative data on the survival of bacteria on fabrics. The data showed that the organisms remained alive in sufficient numbers and for sufficient periods of time to be of epidemiological significance. Simulated warm-water laundering did not have appreciable antibacterial action on inoculated swatches of fabrics, but introduction of either a quaternary or a phenolic disinfectant during the laundering process produced a marked reduction in the number of bacteria on the fabrics.

The types and numbers of bacteria on naturally-soiled clothing and household textiles and the extent to which these bacteria survived "warm" and "hot" water home-type laundering were determined in laundry, from nine families, washed weekly for several months in the laboratory in an automatic household washer. The number of bacteria recovered from wash water to which no disinfectant had been added varied from 80 to 84,000 per ml. at the hot water setting and from 2,120 to 340,000 at the warm water setting. When no disinfectant was added during rinsing or washing, the number of bacteria recovered from rinse water varied from 30 to 32,000 per ml. after hot water washing, and from 870 to 41,000 per ml. after warm water washing. Bacterial counts on swatches of "clean" fabric that had been washed with soiled articles provided evidence that redeposition of bacteria occurs during both "hot" and "warm" water laundering. The addition of either a quaternary, a phenolic, or a hypochlorite disinfectant at some step in the laundering process, consistently and appreciably reduced the numbers of bacteria. Of more than 1,500 strains of bacteria isolated from the wash and rinse cycles and the fabric swatches, 400 were identified as belonging to 30 species. Of these, the potentially pathogenic bac-

teria Staphylococcus aureus, Pseudomonas aeruginosa, and a species of Paracolibactrum are of most importance from the standpoint of household hygiene.

Reports of this research were given at national meetings of the Chemical Specialties Manufacturers Association in May 1961 and May 1962, and of the American Institute of Biological Sciences in August 1962.

In cooperation with other members of a Research Committee of the American Association of Textile Chemists and Colorists, a quantitative procedure for the evaluation of antibacterial activity of treated fabrics was developed and a qualitative procedure was revised.

C. Household Methods for Reconditioning and Storage

Causes and prevention of color changes in textiles. As reported previously, the causes of the yellowing of cotton clothing and household textiles which accompany repeated use and laundering were investigated, and reports of the completed work are now being prepared for publication. Results indicate that oily and nitrogenous soils are incompletely removed by typical home laundry methods and that both types of soil contribute to yellowing, but do not account for all of the discoloration that occurs during use, laundering, and storage. Oxidation products of skin fat appeared to cause the largest part of the yellowing attributed to oily soil. Hypochlorite and perborate bleaches appear to whiten fabrics by bleaching oily soil rather than by removing it.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Detergents, Bleaches, and Other Agents

Furry, M. S., Bensing, P. L., and Johnson, M. L. 1961. Color effects produced in nearly white fabrics by household detergents. Am. Dyestuff Repr., 50(2), P. 50-55, illus. (Abstract published in Jour. of Home Econ. 53(5), p. 363, 1961.)

Furry, M. S. 1961. Detergents for home laundering. Home and Garden Bul. No. 49, 8 pp. Slightly revised.

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AREA NO. 3. RURAL FAMILY HOUSING AND HOUSEHOLD OPERATIONS

Problem. Much of present-day farm housing is obsolete and in need of replacement or major repairs. Technological advances of many kinds are affecting the kind of work and leisure time activities carried on in rural homes and consequently are creating changes in housing needs. For designing and remodeling houses for families at different income levels, architects, designers, lending agencies, and others helping rural families, need research-based standards for work and storage spaces. They are asking also for guides for efficient arrangement of house interiors. As a basis for the design of houses that meet modern family requirements, a continuing program is needed to determine the type and scope of household activities, patterns of use of water, electricity, and gas; dimensions and arrangements of space required for work and for use and storage of equipment and housefurnishings; comparative human energy costs involved in using housing facilities of different designs; and the advantages and disadvantages of various types of interior finishes. Improved procedures for performing household work are needed to maximize return from input of human skills and material resources.

USDA PROGRAM

The Department has a continuing program involving home economists, housing specialists, physicists, and architects. They conduct investigations of the rural housing requirements of people and interpret findings of these and other studies for use by families, architects, builders, and others working with families, in planning for adequate dimensions and efficient arrangements of interior space; adequate water supplies; adequate and convenient use of electricity; and good environmental conditions of light, temperature, humidity and noise levels. Also included are designs for functional built-in storage facilities and guidance in the selection and care of interior finishes.

To identify housing problems and determine relative urgency from the national standpoint of various phases of applied research, field studies are conducted from time to time among farm families in regions which differ in geographic or climatic conditions. As needed, pilot studies are conducted to establish research procedures and provide appropriate instrumentation for investigations in the field or in the laboratory. The human energy costs of performing household tasks using housing facilities and mechanical equipment of different designs are determined to supplement the data being obtained on space requirements in developing criteria for efficient arrangements of kitchens and other areas of the house.

Development of standards and planning guides includes consideration of the needs of 1) lending agencies (particularly the Farmers Home Administration) for basic principles and guides especially related to adequacy of house plans from the occupants' standpoint; and 2) architects, designers, builders, and others who assist families with planning problems. Such guides are also available for use in the Rural Areas Development Program.

Plans for rural dwellings are developed for distribution through the Cooperative Farm Building Plan Exchange program carried on by the Clothing and Housing and the Agricultural Engineering Research Divisions of the Agricultural Research Service, the Federal Extension Service, and the Land-Grant Colleges.

Most of the research is conducted at headquarters in Beltsville, Md., in close cooperation with the Agricultural Engineering Research Division and, for special investigations from time to time, in cooperation with State Experiment Stations. The Federal scientific effort devoted to research in this area is 7.0 professional man-years.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

At the State Experiment Stations various aspects of rural family housing were under investigation through regional research effort or as individual Station undertakings.

In the matter of family requirements for space, research was conducted on family living centers with special attention to multiple use of space and facilities. Another study was conducted to establish basic dimensions for storage units for folded garments; these units being designed as storage walls and evaluated in home situations.

There was cooperative endeavor to obtain practical information on the effects of solar radiation on dwellings as a basis for designs to utilize such radiation or to modify its effects. Special attention was given to influence of the sun on house comfort, durability, and economy.

Researches on materials and finishes for interior use involved investigations of materials adapted for use in sliding, folding, and swinging doors, either between rooms or as closures for swinging doors. Window types and designs, as well as materials and finishes, were compared and evaluated as to cost, performance, and suitability. Rural family experiences with soft floor coverings were evaluated to establish basic principles associated with satisfaction. Research on hard floor surfaces considered factors of safety, appearance and ease of cleaning in confined spaces. Special

attention was given to stairs in a laboratory approach concerned with friction characteristics.

As a basis for house planning guides for the aged, field studies in representative areas established some of the actual problems of this age group, associated with both physical and emotional needs.

Research to establish basic knowledge of the physiological costs of performing household tasks was conducted with reference to work methods, design of tools, and physical surroundings. Special attention was given to energy requirements of both younger and older women in climbing and descending stairs, with and without carried loads.

Some consideration was given floor plans from the standpoint of remodeling certain types of older houses. Other research explored combinations of space standards of individual units that would be feasible and compatible when assembled into living units.

Problems experienced by homemakers in the conduct of household operations prompted investigations to identify characteristics of the problems and to provide practical guidance in alleviating them. The organizational aspects of homemaking received attention in order to point up alternatives for controlling the work itself, or changing certain conditions associated with it.

Some 16 Stations participated in the research in this area, with a total effort of 9.4 professional man-years.

Manufacturers, trade associations, and privately-owned research laboratories conduct research in certain phases of home building and home operation and, occasionally, on housing needs and preferences of particular segments of the population. Manufacturers of resilient floor and countertop coverings, wall tiles, and other interior finishes establish methods of installation and care that promote a satisfactory service life of their products and support research to evaluate the efficiency of the product in relation to the materials on which it is to be used. Test procedures sometimes are developed. Findings related to the performance of specific materials and products are kept confidential; those relating to a class of materials occasionally are reported in trade magazines. Consumer testing laboratories investigate for the benefit of the members of their organizations and subscribers the performance and physical characteristics of such interior finishing materials as floor coverings and paints, and the cleaning supplies and protective coatings used in the care of these materials. Estimated annual expenditures are equivalent to 100 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Family Requirements for Space, Water, Light and Other Needs

1. Space requirements around individual pieces of household equipment and furniture, and for such elemental activities as walking, reaching, and bending, were established, based on measurements obtained in five parallel studies conducted by CH and the Agricultural Experiment Stations of Alabama, Illinois, Pennsylvania, and Washington. Measurement data obtained on a total sample of 230 women were supplemented with similar data on a small sample of 20 men, measured at the Alabama and Illinois Stations.

By agreement of leaders of the five projects, recommended space allowances for any specific activity were set at the value of the mean measurement, in inches, plus (or minus, in appropriate instances) one standard deviation from the mean, rounded to the next highest even inch. Dimensions thus obtained satisfied the minimal space needs of 80 percent or more of the subjects studied.

On the basis of these calculations, the recommended clearance (horizontal space, measured perpendicularly from the front edge of equipment) in front of kitchen equipment is 36 inches for base cabinet, refrigerator, and wall oven, 38 inches for a conventional range, and 42 inches for a front opening dishwasher. These clearances are recommended for a kitchen in which one person normally works alone and which is not used as a passageway to other parts of the house. In kitchen design for situations where it would not be feasible to vary the amount of clearance in front of individual pieces of equipment, 38 inches is recommended. If two or more persons work together, or if the kitchen is also a passageway, an additional 16 to 22 inches of clearance should be added to the allowances to permit free movement of persons around each other.

Recommendations for space around dining tables reflect the several factors that influence the space requirement: type of chair--arm or armless; table, freestanding or with one end against the wall; and whether or not passage space is desired behind the chairs of seated persons.

The clearance recommended for making a bed is 22 inches at the sides and foot, while 40 inches of clear space is recommended in front of furniture with drawers.

Clearance of 42 inches in front of a closet is recommended when the closet-use activity is likely to be combined with a post-use activity such as putting on a coat or assembling articles removed from the closet. The clearance can be decreased to 36 inches if space in front of the closet is only for the closet-use activity.

Space needed for cleaning under furniture was ascertained using three cleaning tools--mop, canister and upright vacuum cleaners--and three pieces of low furniture differing in their front-to-back dimensions--bookcase, double bed, and davenport. More space was used when cleaning was done with the vacuum cleaners than with the mop; about the same amount of space (4 feet) was needed when the vacuum cleaner was used under a narrow piece of furniture as under a wide one. On the basis of the measurements obtained, the clearance allowance for cleaning activities was established at four feet of easily accessible space.

Small variations between individuals were found in the elemental activities of walking and bending, and large variations for reaching. The mean widths of space used by women and men when walking with arms down was 4.3 and 5.0 inches greater, respectively, than the means of the maximum body-width measurements, indicating the amount of body sway. An allowance of 26 inches is recommended to provide enough space for walking--for both men and women. An allowance of 16 inches provides space to edge past an obstacle of chair-back height.

These and other basic dimensions resulting from measurement of space used by the body at rest and in motion, together with dimensions of typical kinds of furniture commonly used in homes, were used in various combinations to develop overall dimensions for work and leisure areas. The standards take into account the kinds of furniture usually used together in an activity area, the differences between these pieces of furniture in respect to their clearance requirements, the difference between the amount of space needed to use a piece of furniture and that needed to care for it, and the degree to which clearances can be overlapped when the house planning problem demands that space be kept to a minimum and when allowances can be more liberal. A popular report of the study was published in May 1962 by the Illinois Experiment Station, and preparation of the technical report is in progress.

2. Water requirements of farm households are being explored in two preliminary phases of a study which are under way concurrently, following pretests of 1) newly developed instrumentation for metering and recording water consumption data, and 2) forms for collecting data through observation and interview. Families installing water systems for the first time and those who are stepping up demand on their existing systems through installation of new water-connected equipment need information on water requirements for various household tasks (as well as for the farm enterprise).

The first phase--determining the amounts of water used in present-day farmhouses--is cooperative with the Agricultural Engineering Research Division which took leadership in developing a portable

metering and data-recording unit for measuring quantities and/or duration of waterflow through individual outlets in the farmhouse and elsewhere on the farm. Metering and observations of household water-using activities were started during the summer of 1962. Water supply lines of 12 farmsteads will be metered for periods of one week every three months during the first year of data collection. Four of the houses have been prepared to receive the portable instrument unit.

The second phase of this research will be a field study of the kind and scope of water-using activities in farm households, designed to show the influence of household size and water-using practices on the quantity of water used. Water used in farm homes included in the field study is not being metered; instead, the quantitative data obtained from the farmhouses studied in phase 1 is to be applied to the descriptive information obtained by the interviews conducted in phase 2 to make estimates of water used for the various household processes. For the field study, a random sample of 84 segments in the open country of five Maryland Counties--Carroll, Frederick, Howard, Montgomery, and Prince George's--was drawn by the Survey Statistics staff of the Consumer and Food Economics Research Division who also prepared sampling instructions, record cards, and other field forms needed for recording and reporting progress on sampling. These segments are expected to yield about 200 schedules from eligible households. CH prepared instructions for interviewing and taking the schedules; plans for coding and tabulating data are under way. Two 2-person teams of interviewers were trained in sampling and interviewing techniques for one week prior to actual field work which started in June 1962.

B. Interior Designs, Standards, and Planning Guides

1. The program of application of dimensional standards to interior house design went forward on several fronts, translating results of research on family housing requirements into forms readily usable by professional designers, builders, and farm families.

The preparation of new and revised farmhouse plans for the Cooperative Farm Building Plan Exchange was continued in cooperation with the Agricultural Engineering Research Division of the ARS, the Federal Extension Service, and the State agricultural colleges. The Clothing and Housing Research Division is primarily responsible for interpreting to the architects the results of research on space requirements, efficient arrangements of space and equipment, and other functional requirements, so that they can be incorporated into all plans developed for the Plan Exchange.

Nine plans, either new designs or time-tested ones revised to incorporate recent research findings, were completed between September 1960 and July 1962, and several other plans are in process. These designs vary in size and features, from a 1-room cottage with solar-type heating to a 5-bedroom house with fallout shelter. The solar house is an alternate version of a plan originally designed for conventional heating, now adapted to incorporate results of research by the California Experiment Station on utilization and control of solar energy for housing. One plan is the third in a series that incorporates a Beltsville energy-saving kitchen design; another is the first truly modular house in the Plan Exchange, a design for post and beam construction, submitted by the Illinois Experiment Station. One new and one revised design are particularly planned for use of retired or young couples.

Two-page leaflets were prepared for each completed plan. The leaflets, used in the states to inform farm families of the types of house plans available, show an exterior view of the house, the floor plan, the plot plan, and an interior view; and describe the outstanding features of the design by which the farm family may judge the plan's suitability to their needs.

The Southern Plan Exchange Committee was reactivated in 1961 with eight States and Puerto Rico represented. This Committee, paralleling one in the Western Region which has been active since 1956, gives guidance to the work of the Plan Exchange. Although the house plans are developed in cooperation with specific regions, reproducible transparencies are sent to all states.

The research on energy-saving kitchen designs, which resulted in three basic designs and many design features applicable in building and remodeling, is nearing completion. A leaflet describing the third kitchen design, with dimensioned drawings of all special features, was prepared and is currently being processed by the Information Division. The designs for this kitchen and its two predecessors incorporate results of previously reported research on space requirements and on desirable arrangements in housing facilities of different design. A paper entitled "A basic approach to kitchen design" was presented at the 43rd Annual Meeting of the American Dietetic Association in Cleveland, Ohio, in October 1960. A technical report on the experimental work underlying the development of the kitchen designs is being postponed, pending completion of a series of popular publications giving practical applications of findings from this and other recent research on designs and dimensions for rural house interiors. This series of publications is described in section 2 below.

In response to repeated requests for assistance on bathroom planning, a proposed revision for Home and Garden Bulletin No. 19, "Your farmhouse...Planning the bathroom" was drafted. Sketches of special features suggested as illustrations for the bulletin were completed, as well as scaled drawings of 27 arrangements of bathrooms that incorporate the findings of the Maine Agricultural Experiment Station research on space requirements for bathrooms.

2. Standards and planning guides for low-cost housing in rural areas are being developed in cooperation with AE for use by families seeking loans for remodeling or building new homes, and by field personnel helping rural families with their house plans. This work is conducted in part with funds authorized by the Housing Act of 1961. As a basis for planning the work, research leaders visited in five States to determine from state and county Farmers Home Administration field personnel and their client families, the type of planning aids needed, source of present help with planning, the types of homes being built, and problems encountered in designing and building. From this field experience, though limited, it was concluded that a series of simple, largely pictorial, planning aids applicable to low- and medium-cost houses was needed for distribution to families, based on space requirement data and findings of other ARS and State Experiment Station housing research.

A series of 34 leaflets--13 to be prepared by CH, 14 by AE, and seven by the two Divisions jointly--has been tentatively outlined. Preliminary drafts of four leaflets on kitchen planning--parallel-wall, L-, U-, and broken U-arrangements--have been completed, and one--the L-arrangement--was used in developing a sample format for presentation to the USDA Information Division for review and approval of the entire series.

An evaluation of five expansible farmhouses designed by the Cooperative Farm Building Plan Exchange and constructed at the Agricultural Research Center to house dairy workers, which was described in the 1960 Progress Report, was published jointly by CH and AE in 1961. The evaluation of livability made by CH, and of construction and materials made by AE, serves as a guide for planning and evaluating similar expansible house plans. Deficiencies pointed up by the evaluation were remedied in a redesign of one house plan which subsequently was made available to farm families through the Plan Exchange.

Problems of developing guides for planning housing for the elderly low-income urban household were explored upon request of the Commissioner of the Public Housing Authority. Consultation and advisory services were given by CH staff on apartment houses for the elderly being planned by the National Capital Housing Authority. Visits were made to apartments occupied by elderly people in four NCHA

properties, and several working conferences were held with representatives of NCHA and architectural firms engaged to design the project buildings. As a result of these visits and conferences, CH staff developed recommendations for minimum space requirements for work and storage areas in NCHA buildings for elderly occupants, based on standards developed through ARS and State Experiment Station research on space requirements for rural dwellings. To give the architects of NCHA some insight into ways of applying the standards, two study plans of layouts for apartments suitable for housing the elderly were developed. Preliminary drawings of apartment units for the elderly that had been prepared by architectural firms engaged for the NCHA construction program were also reviewed, and suggestions were made for redesigning certain areas, particularly kitchens, to incorporate research-based standards and design principles. Many of these recommendations were incorporated in the architects' final design.

C. Household Operations

1. Identification of working and storage heights which require the least work is serving as one basis for designing housing facilities. In the most recent series of investigations, energy expenditures of women working at equipment of different heights in the kitchen, laundry, and bathroom were measured.

One aspect of the work--a comparison of energy expended for work done in the sitting and standing positions--was reported to the Research Section of the American Home Economics Association at its annual meeting in Cleveland, Ohio, in June 1961, and was published in the Journal of the American Medical Women's Association in November 1961.

For the activities studied, energy costs for standing to work were found to be significantly less than for sitting to work, at least for short periods of time. Although the mean energy expenditure for standing quietly was 6 percent greater than for sitting quietly, selected activities performed when standing required less than the same activities carried out when seated. For example, washing dishes while sitting required 4 percent more energy than washing while standing. This relatively small but statistically significant difference was increased when the measurement included getting on and off the stool: the energy expenditure while sitting down to wash dishes was then found to be 13 percent greater than washing dishes while standing.

Comparative values for other activities studied--ironing, using storage shelves above a work counter, and rolling dough--showed a similar pattern: energy expenditures for working in a standing

position were less than the sitting activity values. Advice to sit or stand at work should be given with caution, however. The work period in all cases reported here was relatively short--one to four minutes. Other factors, as well as the influence of the length of the work period, need to be explored. Furthermore, energy expenditure is only one factor that contributes to fatigue. A publication now in preparation will incorporate all completed phases of these studies on the energy requirements for performing tasks while sitting and standing at various working surface levels.

In progress are investigations of the costs in human energy of household activities involved in the care and cleaning of the home. Laboratory work is under way on determination of energy expenditures of women using three types of vacuum cleaners.

2. Work continues on compiling reference lists and information on methods and materials for maintenance of interior finishes and on guides for making existing storage and work areas more functional. These materials are presently used in correspondence relating to house care and maintenance problems, and ultimately will serve as background information for research on methods of care that make best use of time, money, and skills.

D. General

The growing public awareness of unsolved problems of the elderly population is being felt in increased demands for consultant and advisory services of the Clothing and Housing staff. In addition to the previously mentioned service project for NCHA, a staff member served as a resource person on housing requirements at a Workshop on Aging sponsored by the American Home Economics Association (Purdue University, 1962) and at an Institute on Producing Housing for Older People sponsored by the National Committee on Aging, the Institute of Physical Medicine and Rehabilitation, and the National Housing Center (New York City, 1961). A file of publications relating to housing for the aging is being maintained in the Division for use in handling current inquiries and in possible future research on requirements and standards for housing for the elderly.

Two articles were prepared for recent issues of the Yearbook of Agriculture. "Technology in homes," published in the 1960 Yearbook, traces the development of household equipment and the influence of labor-saving equipment on family living patterns and house design. "The house on the farm," a section of the 1962 Yearbook, tells of the changes that have taken place in design of rural houses over the past 100 years, and of the research that has contributed toward making rural homes more functional.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Family Requirements for Space, Water, Light and Other Needs

McCullough, H. E., Philson, K., Smith, R. H., Wood, A. L., and Woolrich, A. 1962. Space standards for household activities. Univ. of Ill. Agr. Exp. Sta. in coop. with Ala. Agr. Exp. Sta., College of Home Econ., Pa. State Univ., Wash. Agr. Exp. Sta., and CH, ARS, USDA. Bul. 686, 16 pp., illus.

Interior Designs, Standards, and Planning Guides

CHRD and AERD. 1960. 3-bedroom farmhouse incorporating Beltsville energy-saving kitchen design no. 2. Plan 7152, USDA Misc. Pub. 829, 2 pp., illus.

_____ 1960. 2-bedroom farmhouse with basement. Plan 7157, USDA Misc. Pub. 830, 2 pp., illus.

Biggs, A. A., and Courtless, J. C. 1961. Evaluation of construction, materials, and livability of five expansible farmhouses. USDA, ARS 42-45, 29 pp., illus.

Southern Regional Housing Res. Tech. Comm. 1961. Home sewing areas. Sou. Coop. Ser. Bul. 58, Suppl. A, 8 pp., illus. (AERD and CHRD cooperating.)

CHRD and AERD. 1961. 3-bedroom farmhouse with attached two-car garage. Plan 7132, USDA Misc. Pub. 842, 2 pp., illus.

_____ 1961. 2-bedroom farmhouse with basement. Plan 7159, USDA Misc. Pub. 876, 2 pp., illus.

_____ 1961. 2-bedroom farmhouse with slab-on-grade construction. Plan 7160, USDA Misc. Pub. 877, 2 pp., illus.

_____ 1962. 2-bedroom farmhouse...with carport. Plan 7156, USDA Misc. Pub. 897, 2 pp. illus.

Howard, M. S. 1961. Energy-saving kitchens--A basic approach to design of work areas. J. Am. Diet. Assn., 39(3), P. 201-204, illus.

Household Operations

Richardson, M., and McCracken, E. C. 1960. Energy expenditures of women performing selected activities. USDA, Home Econ. Res. Report 11, 24 pp.

Anonymous. 1961. Energy used by women in various activities.
Family Economics Review, ARS 62-5, pp. 14-15.

Richardson, M., and McCracken, E. C. 1961. Energy expenditures
of women performing selected activities while sitting and stand-
ing. J. Am. Med. Women's Assn., 16(11), P. 861-865.

General

McCracken, E. C, Woolrich, A. M., and Holmes, E. G. 1960. Tech-
nology in homes. USDA, Yearbook of Agriculture. pp. 403-415,
illus.

Woolrich, A. M., and Howard, M. S. 1962. The house on the farm.
USDA, Yearbook of Agriculture, pp. 658-663, illus.

AREA NO. 4. HOUSEHOLD EQUIPMENT AND NONTEXTILE FURNISHINGS

Problem. Homemakers are asking for information on the selection, use, and care of different designs of household equipment and of different types of furniture and other nontextile furnishings. To obtain the information needed for such guidance, the development of test procedures and performance requirements is essential. These procedures and performance requirements are also needed for incorporation in Federal Specifications which are used for government purchases of household equipment, and in American Standards which are widely used by testing agencies and manufacturers who desire to put better adapted products on the market and label them so that consumers will know the performance that can be expected. Information on performance characteristics of various designs of equipment for cooking, refrigeration, laundering, cleaning, and other household tasks are also needed as a basis for development of semitechnical materials urgently requested by Extension Service personnel, teachers, and others working with farm families.

USDA PROGRAM

The Department has a continuing program of research on household equipment and nontextile furnishings which involves home economists, physicists, microbiologists, and chemists. They determine the performance characteristics of different designs of equipment under conditions representative of household use. The results provide a basis for unbiased information for consumers in selecting from models of ranges, refrigerators, washers, vacuum cleaners, and other equipment available on the market, the design and special features that meet their particular needs. Research is also conducted to determine performance requirements for household equipment as a basis for advice to manufacturers in improvement of designs for food-related and textile-related equipment, and for items used in cleaning interior surfaces in the home. Test procedures for these determinations are developed as necessary. The research is carried on at Beltsville, Md., and involves approximately 5.0 professional man-years. Manufacturers cooperate in this work by giving consultation in the selection of equipment and development of test procedures in many instances, and by consigning household equipment for use in laboratory investigations.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

Research at the State Experiment Stations included a study of the buildup of temperature and humidity within the kitchen during cooking operations on standard household ranges and supplementary cooking appliances. Another investigation was concerned with the

performance of thermostatically controlled gas burners and electric units for top-of-the-range cooking. Special attention was given to the effect of utensils of different materials on the operation of the sensing element of the thermostat. Another aspect of the research dealt with requirements of equipment and furnishings in terms of heights and other characteristics adapted to the functional needs of the user.

These investigations, involving the efforts of three Stations, totaled 1.1 professional man-years.

In industry, equipment manufacturers determine performance characteristics of different designs. Certain trade associations also conduct research directed toward the development of new or improved products and a few, such as the American Gas Association, test equipment to determine and give recognition to its compliance with established standards. Testing laboratories, such as Consumers Union and Consumers' Research, investigate for the benefit of their members and subscribers to their magazines, the performance of selected models of different kinds of household equipment available on the market at a given time. Test procedures and to some extent functional requirements for equipment developed by these organizations are developed primarily for their own use but they are frequently made available to government research agencies and for consideration as American Standards and Federal Specifications.

Estimated annual expenditures for this work, some of which contributes to consumer-oriented research on household equipment, may be equivalent to approximately 500 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Operating Characteristics, Use, Maintenance, and Care of Equipment

1. Refrigerators and refrigerator-freezers have been under study to determine their operating characteristics and the temperatures actually attainable in compartments designated for storage of frozen foods. Sixteen representative models of household refrigerators, both with and without separate freezer compartments, were included in this aspect of a concerted attack being made by government and industry on problems of maintaining quality of frozen foods from processing plant to the consumer's table. The Division's responsibility in this broad program was to study temperature patterns and operating characteristics of conventional refrigerators and combination refrigerator-freezers under different conditions of use, as a basis for guidance to homemakers on selection and use of refrigeration equipment, particularly from the standpoint of maintaining quality in stored frozen food.

The refrigerator-freezers studied were, in general, found to be satisfactory for the maintenance of quality in frozen foods, using as a criterion a temperature of 0° F. which is generally accepted as necessary for longtime maintenance of frozen food quality. Of the 12 refrigerator-freezers studied, eight attained an average temperature of 0° F. or lower in their frozen food compartment when located in a 90° F. room with an average temperature in their general storage compartment of 39° F. With the thermostats set to give an average temperature in the general storage compartment of 32° F., average frozen food temperatures ranged from -7° F. to 8.7° F.

The four refrigerators of the conventional type, i.e., with a horizontal evaporator instead of a separate freezing compartment, did not keep the temperature within the evaporator where ice cubes are frozen and frozen food stored at 0° F. or below. With the thermostat of these refrigerators set to give the "standard" temperature of 39° F. in general food storage and operating in a room at 90° F., the frozen food temperature ranged from 12.2° F. to 21° F. With an average temperature of 32° F. in the general storage compartment, average frozen food temperatures ranged from 3.5° F. to 12.5° F. In all cases, at an average cabinet air temperature of 32° F., food in some parts of the refrigerator would freeze. Lower room temperatures tended to give higher average frozen food temperatures and higher room temperatures, lower frozen food temperatures; for example, in only one instance, with a cabinet air temperature of 32° F. in a room at 110° F., was an average frozen food temperature of 0° F. reached. Conventional refrigerators, therefore, should always have the thermostat set at the lowest setting that will not freeze the food in the general food compartment, if frozen food is to be stored. Storage time should not be more than a few days if quality is to be maintained.

Since most 2-door combination refrigerator-freezers on the market provide storage shelves on the door of the low-temperature compartments, temperatures were taken at the center of packages stored on these shelves. The readings ranged from approximately 8° F. to 23° F. above the recommended temperature of 0° F. Door shelves should, therefore, be considered primarily a convenience feature contributing to easier management of the frozen food storage space, and used only for short-term storage.

Packages of food at 50° F., to simulate the temperatures that might be expected in food prepared for freezing at home, were introduced into the low-temperature compartment of conventional refrigerators. This resulted in little change in the temperature of frozen foods already in storage, provided that the new packages were kept from contact with the previously stored ones. In the refrigerators studied, the average temperature increase of frozen foods in storage ranged from 1.3° F. to 3.0° F., but temperatures of frozen packages in contact with unfrozen ones rose 5.0 to 7.0 degrees. In the refrigerator-

freezers, under the same conditions, temperature increases were greater: the average increase for all frozen foods in the compartment ranged from 1.5° to 8.8° F. while the increase for frozen packages in contact with unfrozen ones ranged from 8.0° to 13.0° F.

Packages of food at 25° F. to simulate the temperature that might be expected in frozen foods that have warmed during transit from the grocery store to the home were introduced into the low-temperature compartments of conventional refrigerators. This caused an increase of less than four degrees in temperatures of previously stored packages, on the average, but caused an increase from seven to 10 degrees in single packages in contact with the new ones. In the refrigerator-freezers, under the same conditions, average temperatures of previously stored foods increased from 2.0° to 12.7° F., with temperature increases in contact packages from 10.5° to 26.0° F. The rise in temperature in the frozen food in conventional refrigerators was less than in refrigerator-freezers. The greater temperature changes in the electric refrigerator-freezer when thermal loads were introduced were probably due to one or more causes: in the conventional refrigerator, the rise in temperature in the general storage space, due to opening the door, activates the thermostat and, because the evaporator coils surround the low-temperature storage space, the frozen food receives the immediate benefit of the lowered temperature in the coils. In the combination refrigerator-freezer, while opening the door may activate the thermostat, the design of the refrigeration system is such that not as large a percentage of the refrigeration is available in the frozen food compartment as is the case with the conventional refrigerator. Also, a greater thermal load was imposed in the combination refrigerator-freezers because of their greater frozen food storage capacity.

Temperature changes of frozen food during defrosting of the equipment differed among cabinets, due primarily to differences in defrosting procedure. All indications point to the conclusion that elevation of frozen food temperatures during cyclic defrosting was of little consequence in respect to accelerating the rate of quality loss of foods. Manual, semiautomatic, and clock-initiated defrosting, however, resulted in a rise in temperature in frozen food compartments ranging up to approximately eight degrees. When this type of defrosting takes place daily, this much change in frozen food temperature may be a factor in the maintenance of quality.

As would be expected, the cost of operation of a household refrigerator or refrigerator-freezer, estimated on the basis of consumption of electricity or gas, was increased when the temperature setting in the general storage cabinet was lowered or when ambient (room) temperature was increased. Impositions of thermal load in the whole cabinet or in any compartment through such operations as excessive door open-

ings or putting in materials at higher temperatures also increased the cost. Estimated cost of operation was greater in the models of higher capacity but the cost per cubic foot diminishes with increase in size.

Refrigerator-freezers used more electricity or gas than conventional refrigerators, and 2-door models used more than single-door combinations. The higher costs of operation in each case, however, were accompanied by lower frozen food storage temperatures and hence better conditions for that type of storage. Results indicated that frost-free models (those with forced air circulation) can cost up to twice as much to operate as do their counterparts in which frost is deposited in the storage cabinet. The additional cost is not entirely due to increased compressor operation, but includes the energy required to operate the fan that circulates the air in the cabinet and the heater that speeds up the defrosting of the hidden coils. The refrigerators and refrigerator-freezers with forced-air circulation had a more uniform temperature distribution in the entire storage space (including doors) than those of other types and less variation in average storage temperature at different ambient temperatures. In cabinets without forced-air circulation, temperatures in door-storage areas and in hydrators generally averaged several degrees higher than in the main storage spaces.

A technical report of the results has been submitted to the American Society of Heating, Refrigerating and Air-Conditioning Engineering Journal for publication. Semitechnical and popular materials, based on the work, are under consideration.

2. Mechanical home dishwashers are being studied with respect to their operating characteristics in removal of food residues and microorganisms from tableware, and as a basis for the development of performance requirements. Fourteen representative dishwashers selected with the assistance of a committee from the National Electrical Manufacturers Association and consigned by manufacturers were included in the study. Because a standardized test procedure for evaluating the performance of dishwashers in the home was not available, development of realistic methods is the objective of the first phase of the study.

Food soils that are hard to remove were identified in the initial laboratory work, and were then used as a basis for developing a standard soil that could be applied artificially, yet would give a response in dishwasher tests comparable to washing naturally soiled tableware in the home. Particularly sought were: a tenacious soil typical of that found on plates and other large items washed in lower racks; a second tenacious soil typical of that found on smaller dishes and glasses washed in upper racks; and an insoluble material typical of those soils which redeposit during washing.

Test dishes were placed in the cafeteria line for obtaining lunch-dinner type soils; for breakfast soils, food was prepared and eaten in the laboratory. Dishes were washed in four of the 14 dishwashers; cycles were controlled to give a wash and two rinses. Dishes were evaluated by visual inspection as "clean" or "not clean." Among soils left on washed plates was a hard, colorless film which appeared as streaks or smears on the top surfaces.

The hard, colorless film was not found in tests with any of six experimental, hand-applied types of soils reported by manufacturers as being used in their testing laboratories. In the two machines used, only one of these six soils acted like naturally-applied foods in the percentage of clean items from a test load and in showing differences between the two dishwashers.

Based on results of the studies reported above, a food soil was developed which provides the three types of food soils sought, including the film-producing soil. Since the manufacturers were changing the machines in the study for new models, a preliminary evaluation of this soil was made in all 14 of the models consigned. Results correlated well with results using naturally-applied soil, indicating that the soil may provide an adequate basis for evaluating dishwasher performance.

Currently work is under way on comparing the laboratory-developed soil with a breakfast soil, and two soils being used in industry, under varying conditions of use such as water temperature, type and concentration of detergent, and water hardness. From these tests a standard soil will be selected.

Procedures are also being developed for the enumeration of micro-organisms on the surface of the tableware.

3. Automatic portable cooking appliances were studied with respect to their operating characteristics and cooking performance as compared to similar cooking processes performed with electric ranges. In this exploratory study, two samples, each of different manufacture, of five portable appliances--saucepan, saucepot, frypan, roaster oven, and rotisserie oven--were used. Two standard electric ranges, each of different manufacture, were used for direct comparison with each type of cooking process used.

For performance tests of cooking processes commonly done on top of the range, automatic appliances were combined into sets consisting of a frypan, saucepan, and saucepot. One set was of aluminum, and was matched for the tests with a nonautomatic set of similar size, shape, and material, used on an electric range. The second set of automatic utensils and their nonautomatic counterparts was of stainless steel, aluminum-clad. Each set of utensils was tested for

performance of seven cooking processes: braising, boiling, deep fat frying, pan frying, simmering, steaming, and baking. Results showed that cooking time and temperature as suggested by the manufacturer frequently did not give satisfactory products. By modifying the directions, however, acceptable products were obtained with both the automatic utensils and the ranges. In all cases, the appliances gave products that were as acceptable as those cooked on the ranges.

Portable ovens (roaster and rotisserie) were compared with range ovens for 1) ability to maintain a low temperature--250° F.;

2) evenness of heat distribution at 250°, 400°, and 450° F.; and
3) adequate heat in lower unit for setting pastry. Baking temperature, time and rack position as given by the manufacturer were used in the initial tests. When these conditions did not give acceptable products, as judged by the laboratory staff, they were varied until acceptable products were obtained. It was found possible to obtain satisfactory products for the test foods with roaster and rotisserie ovens as well as with the electric ranges.

Meat patties and toast were used to test evenness of heat distribution of portable oven broilers and range broilers. The design of the heating element in the broiler had more effect on the evenness of heat distribution than either type of oven studied.

Management problems encountered and the electricity required when using a "set" of portable appliances for cooking meals were also investigated. Two meals consisting of some of the foods which had been previously used for testing the performance of portable appliances were cooked by one set of automatic utensils and a rotisserie oven and by a comparable set of top-of-range utensils and an electric range. It was found that cleaning the automatic utensils required more time than the cleaning of the nonautomatic counterpart but, when time for cleaning the cooking counter and range top was included, the total cleanup time was the same.

Results of laboratory work have been evaluated and a technical report for publication is being prepared.

4. As previously reported, home laundry equipment was studied intensively during the past several years. During 1960-62, a series of three technical papers was prepared; two have already been published. Findings from Department research and other sources are now being interpreted from a practical standpoint for a popular publication on home laundering to replace Farmers' Bulletin No. 1497 "Methods and equipment for home laundering."

B. Performance Requirements for Equipment and Furnishings

Iron soleplate temperatures that produce smoothness without damage to present-day fabrics are being determined to provide hand iron manufacturers a scientific basis, not now available, for designing an appliance that will perform satisfactorily on the multitude of fabrics available to consumers today. Such improved designs for hand irons would greatly assist homemakers in caring for these fabrics.

The range of hand iron soleplate temperatures effective for removing "washed-in" wrinkles from 43 test fabrics has been investigated. Laboratory work has been completed, data are being analyzed, and a technical report is being prepared.

C. Development of Specifications

In cooperation with the American Standards Association and the Federal Supply Service, the Division continued its participation and, in some instances, took leadership in committee work of preparing standard test procedures and Federal Specifications for household equipment.

The revised Federal Specification for electric water heaters was promulgated during this period. An Interim Federal Specification for electric ranges was completed and circulated to industry and government for comment and for optional use by all Federal agencies. CH staff was responsible for preparation of these Specifications.

The necessary conferences and correspondence have also been conducted with representatives of industry concerning the possible revision of ASA standards for household refrigerators and home freezers, and the preparation of a draft for an international standard for the construction and methods of testing of household refrigerators.

Early in 1961, industry and public utility groups reached agreement on a leakage-current value and method of test to be included in American Standards for those electric housewares for which leakage-current tolerances are critical. The approved test procedure is being incorporated into the revision of C70.1 American Standard for Household Automatic Electric Flatirons, and into the proposed standards for electrically heated bed coverings and for waffle bakers and sandwich grills. When these drafts are approved by the Sectional Committee, they will be submitted to the American Standards Association for consideration as American Standards.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Operating Characteristics, Use, Maintenance and Care of Equipment

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Development of Specifications for Household Equipment

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1961. Federal specification W-H-196d, heater, electric, water, storage, domestic. USDA, ARS.

* Discontinued during report period
** Initiated during report period

